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## ***Appendix I***

### **Air Force Information Warfare Center San Antonio, TX**

**TYPE OF FACILITY:** Database Archive

**POINT OF CONTACT:** AFIWC/DBES  
102 hall Blvd, Suite 331  
San Antonio, TX 78243-7033  
Phone: (210) 977-2778 [DSN: 969 ]  
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**PERTINENT FUNCTION:** Data Archive and Distribution

**FACILITY DESCRIPTION:** Serves as the single Air Force focal point for the storage and dissemination of US and Allied signature data. DBES also provides value-added analysis and quality control of data. This data is maintained in a database known as BATS, the Blue Airborne target Signatures database. It is comprised of three types of data: 1) RCS for aircraft, missiles and chaff; 2) Antenna patterns for electronic countermeasures (ECM) equipment; and 3) Infrared (IR) signatures for aircraft, missiles and flares. DBES has the capability to securely store signature data.

**OBTAINING DATA:** Certain parameters are necessary depending on the data desired. RCS requests require specification of the platform and its configuration, emitter frequency and polarization, and azimuth and elevation angles giving the orientation between the emitter and the aircraft. The parameters needed for an antenna pattern request are similar to those for RCS with the inclusion of whether the antenna is mounted on the target or in free space.

**DATA FORMATS:** AFIWC can provide tabulated or plotted BATS data on a variety of media.

**ADVANTAGES OF BATS:** By utilizing BATS database, the customer experiences several advantages: data is readily available, accurate and continuously updated. The centralized location of data reduces research time and allows easy access to the data.

**SUPPORT:** A staff of highly trained and proficient analysts and engineers are also available to answer any questions or concerns via phone or fax.

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## *Appendix II*

### **GLOSSARY OF RCS MEASUREMENT TERMS**

The definitions and explanations below are designed to help those new to the area of Radar Cross Section (RCS) measurements understand the terminology commonly used. Because of the interconnectedness of these terms, many definitions refer to other definitions. A word or phrase in bold face type, followed by the term (q.v.) indicates this. When this is seen, it should be understood that additional information can be obtained by checking the other definition.

**Amplitude taper** - The variation in amplitude of the illuminating radar beam across the target, or in the quiet zone or measurement region of a range. Usually measured from some baseline to the maximum positive or negative deviation from the baseline.

**Analog-Digital Converter** - A device to convert continuous, analog signals to discrete, digital signals. Used to convert radar signals to a form suitable for post-processing in a computer.

**Angular resolution** - The minimum angle by which two targets at the same range may be separated and their respective radar returns individually detected.

**Anechoic chamber** - A room lined with echo reducing material. The material is usually tuned for a specific frequency range. In the ideal case, all echoes are eliminated.

**Antenna beamwidth** - The width of the main lobe of the transmit antenna's beam, measured at the half-power points from the maximum value of the beam. A broad antenna beamwidth generally implies a "flatter" amplitude taper, which yields a more uniform illumination of the target. The tradeoff is that a broader beamwidth tends to illuminate more of the environment, increasing the amount of clutter or background signal, which can adversely affect the measurement.

**Antenna gain** - This is a measure of how well the antenna radiates net power in a given direction, compared to the amount of power input to the antenna, or some other accepted reference, such as an isotropic radiator.

**Antenna pattern** - A plot of the intensity of the radiation received at a given radial distance from an antenna versus angle, relative to a given reference axis. It is assumed that the observation point is in the far-field of the antenna.

**Azimuth** - The line-of-sight angle measured from the front of a target, around the target in the water-line or horizontal plane.

**Background RCS** - The equivalent RCS of a measurement range in the absence of a target.

**Background subtraction** - A method to reduce the corrupting contribution of the measurement environment by using **vector cancellation** (q.v.) of the received signals. To implement this approach, a background measurement (the environment without the target) is made. Then a target measurement (the environment with the target) is made. If a value equal in amplitude and opposite in phase of the background measurement is added to the original background measurement, the resultant will be zero and the background will be canceled or subtracted out. The ability to perform this procedure is dependent upon: 1) the stability of the system at the measurement frequency, with stability being determined by the movement of the components of the measurement environment in terms of wavelengths; and 2) how much of the background is "shadowed" by the target when measurements are made.

**Backscatter** - The radar reflections from a target that are oriented directly back toward the receiving antennas.

**Bandwidth** - The finite range of frequencies in which an electronic device or material may operate effectively. Typically, that portion of the signal that is greater than the half-power value defines the bandwidth.

**Berm** - Mounds of earth that are built up to shield clutter sources in an outdoor range from an illuminating radar beam. Berms are designed to reflect the radar waves in a direction away from the receiving antennas, thereby reducing the amount of clutter signal returned to the antenna.

**Bistatic RCS** - A measure of a target's reflective properties when illuminated by a transmitter and detected by a receiver in separate locations.

**Calibration** - The procedure that endures measured RCS data is related to some RCS standard. This allows the measured data to be compared with other measured data, measured scale model data, and predicted data, or to be used in analysis models in a verifiable fashion.

**Calibration standard** - A target that gives well-known RCS values versus frequency or aspect angles. Use of a calibration standard is required for the calibration process. Typical calibration targets include spheres, cylinders, flat plates, and corner reflectors.

**Cancellation** - A method to eliminate a specific signal by adding to it another signal of equal amplitude but opposite phase.

**Chaff** - Reflective dipoles dispensed into the atmosphere to generate a large RCS in an attempt to hide a target from a tracking radar. The length of the dipole determines its resonant frequency, and thus, the frequency where the dipole looks electrically large.

**Chirp** - A method of intrapulse modulation, used for pulse compression, also called linear frequency modulation. This is accomplished by sweeping the frequency of the radar in a short period of time, usually during the period of a single pulse.

**Circular polarization** - If the vector that represents the electric field (propagating electromagnetic wave) traces out a circle in space, the field is said to be circularly polarized. Circular polarization tends to be used at frequencies above X-band.

**Clutter** - Clutter is the general name given to any unwanted signal that is included in the radar signal returned to the receiver. For instance, in an outdoor range, the return from a hill, a vehicle, or some other feature of the measurement environment would be considered to be clutter. For a dynamic sea range, the return from moving waves would be considered to be clutter, while an indoor range may have the reflection from some structural member contaminating the radar return. Different types of clutter will require different approaches for its elimination.

**Clutter fence** - A fence or **berm** (q.v.) used to minimize the effect of clutter by shielding the clutter from an illuminating radar beam.

**Coherent integration** - Integration is the process whereby many radar returns are summed up, to increase the effective received signal and improve the system sensitivity. If the phase of the returned signal is preserved during the summing process, it is considered to be coherent integration. Coherent integration must be used to preserve phase information if the data is to be processed for imaging purposes.

**Collimated beam** - A radar beam that has all of the energy directed into a low divergence beam that has a uniform phase front. A collimated beam is often used to simulate far-field conditions, where a plane wave of uniform phase washes over a target.

**Collimator** - A device to collimate an electromagnetic wave to simulate a far-field condition. One common form is that of a parabolic reflector, with a feed antenna at the focal point of the parabola. Another common form is that of a microwave lens, typically constructed of a dielectric.

**Compact RCS range** - An anechoic chamber equipped with either a lens or reflector, used to collimate the beam radiated by a feed antenna. The collimated beam simulates "far field" conditions in a fraction of the distance normally required.

**Continuous-wave (CW) radar** - A radar which transmits continuously and simultaneously listens for the reflected returns.

**Conductivity** - The ability of a material to allow the flow of electrons on or through it. A material of high conductivity allows electrons to flow easier than on of low conductivity. To eliminate electrical discontinuities, and the resultant scattering associated with it, a body should have a uniform conductivity as much as possible, with any required changes happening "slowly".

**Co-polarization** - Co-polarized waves are those that have the same electromagnetic sense. For instance, if a radar wave is transmitted using horizontal polarization, the co-polarized wave will be returned as a horizontal wave. The vertically polarized wave would represent the **cross-polarized** (q.v.) wave in this case.

**Corner reflector** - A radar reflector consisting of three flat conducting plates joined together at right angles to one another so as to form a corner. If radiation is incident upon the corner reflector over a broad range of angles, it will be reflected directly back toward the source.

**Creeping wave** - This is an electromagnetic wave that is generated on the illuminated surface of a curved structure and continues to appear on the structure in the shadowed region, due to its attachment to the surface. The wave continuously sheds energy as it travels through the shadowed region, causing a scattered signal to appear in a region that is shadowed from an illuminating radar beam.

**Cross-polarization** - Cross-polarized waves are those that have an orthogonal electromagnetic sense. For instance, if a radar wave is transmitted using horizontal polarization, the cross-polarized wave will be returned as a vertical wave. The horizontally polarized wave would represent the **co-polarized** (q.v.) wave in this case.

**Cross range** - Distance measured normal to the range vector. When making two-dimensional high-resolution RCS measurements of a target, cross-range data is that information obtained when displaying the radar returns from the direction orthogonal to the **down-range** (q.v.) data.

**CW nulling** - A method of eliminating clutter in a range by canceling it out through **vector subtraction** (q.v.).

**Data slide** - The amount a **data window** (q.v.) is advanced when RCS data is processed or averaged.

**Data window** - A small subset of the total RCS data set, used for data reduction or processing.. For instance, a window of 1.0 degree might be selected. All the values within the window might be averaged, and the result assigned to the angle represented by that range. Thus, a data set containing 3600 values, itself coming from the averaging of many other values, could be reduced to 360 values, a 10:1 reduction.

**Decibel** - Unit of level of a power-like quantity (electromagnetic power) when the base of the logarithm is the tenth root of ten. Also, the decibel is the unit of level of a field quantity (voltage) when the base of the logarithm is the twentieth root of ten. *Abbreviated dB, a unit used to express relative difference in power or intensity, usually between two acoustic or electric signals, equal to ten times the common logarithm of the ratio of the two levels<sup>1</sup>.*

**Depolarization** - The process that occurs when a wave is converted from a reference polarization to an orthogonal or **cross-polarization** (q.v.).

**Dielectric Constant** - A constant that refers to the property of a medium which determines the electrostatic energy stored per unit volume of the medium, for a unit potential gradient (electric field). The dielectric constant is one of the properties of a material or a body that can be manipulated to alter its electromagnetic properties, especially the body's ability to absorb or reflect radar waves.

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**Diffraction** - A wave whose front has been changed in direction by an obstacle or other nonhomogeneity in a medium, rather than by reflection or refraction. Mathematically, it is a consequence of maintaining electromagnetic continuity across a **shadow boundary** (q.v.). Physically, it will yield a measurable electromagnetic wave in a region that is not due to a direct, reflected, or refracted wave or ray.

**Directional coupler** - A passive microwave device that allows RF to flow easily in one direction, but with a large amount of attenuation in the other direction.

**Doppler effect** - The change in the observed frequency of an electromagnetic wave caused by relative motion between the source and the observation point.

**Down range** - When a typical RCS measurement is made of a target, the usual information obtained is a (complex) value which represents the summation of the radar returns from various parts of the target, because the entire target is within the radar resolution cell. If a high-resolution measurement is made, with the target consisting of many range resolution cells, then it is possible to resolve RCS variations across the target. Down-range data is that information that is obtained when displaying the return from successive cells obtained the "front" of the target toward the "back" of the target. The data is typically displayed as amplitude vs. a linear distance from some reference point, either the front or center of the target.

**Dwell time** - The amount of time that the radar is illuminating a moving target, or a moving radar beam is illuminating a stationary target.

**Dynamic range** - The difference between the maximum power handling level and the minimum acceptable signal level in a system. (Typically the 1 dB compression point and the system noise floor).

**Dynamic RCS range** - An outdoor measurement range capable of measuring the RCS signature of moving targets in their natural environment (air, land, or sea).

**Effective aperture** - A useful measure of the effective area that a receiving antenna presents to an incident wave. The ratio of the effective aperture to the physical aperture of the antenna is equal to the antenna aperture efficiency. Effective aperture is also related to the gain of an antenna at a given frequency.

**Electromagnetic scaling** - The principle whereby appropriately designed sub-scale models can be substituted for full-scale objects when making electromagnetic measurements or predictions. For instance, if a 50 foot object is to be measured at 10 GHz, the same RCS pattern on a half-scale model is obtained at a frequency of 20 GHz. For this to hold true absolutely, all quantities must be scaled.

**Ellipse of constant delay** - The ellipse of constant delay is the locus of points for which a bistatic interaction path from transmitter to scatterer to test target to receiver is a constant. This ellipse has the transmitter at one focal point and the target at the other focal point. If the range area is cleared of all clutter sources beyond the ellipse of constant delay, then there will be no clutter sources that can return a corrupting signal to the receiver before the direct return of the target. Therefore, the target can be separated from interfering signals by use of a **range-gate** (q.v.).

**Error budget** - A document that defines the various sources of error in a measurement system, as well as the amount of error for each of those error sources. An error budget is critical for determining the ultimate validity of the RCS measurements made.

**Far field** - The distance at which it can be assumed that all of the EM waves from the radar or antenna are planar and maintain a constant relative phase. A common rule of thumb is to use a value for the range from antenna to target of  $2D^2/\lambda$ , where D is the target's largest dimension, and  $\lambda$  is the wavelength in the same units as D. The target region for RCS measurements is usually selected to be in the far-field region of the antenna.

**Field probe** - A device used to measure the amplitude and phase of the electromagnetic field (radar beam) that is illuminating a range.

**Foam column** - A target support structure made of a low dielectric constant material to minimize its RCS. Typical materials are Styrofoam or encapsulated polystyrene (EPS).

**Forward scatter** - Components of the scattered field that proceed in a direction that is the same as the original illuminating radiation.

**Full scattering matrix** - A matrix relating the polarization components of a target's scattered field to the incident field. Measured by illuminating the target with vertically polarized waves and measuring both the vertically and horizontally polarized returns. The target is then illuminated with horizontally polarized waves and the vertically and horizontally polarized returns are again measured.

**Glint** - The random component of target location error caused by variations in the phase front of the target signal. Glint may affect angle, range, or Doppler measurements, and may have peak values corresponding to locations beyond the physical extent of the target in the measured coordinate.

**Grating lobes** - Repetitions of an array antenna's main lobe, occurring at increasingly large intervals on either side of the main lobe. They occur when the spacing between array elements exceeds half a wavelength for a synthetic array, and one wavelength for a real array.

**Ground bounce** - The reflection that occurs on a RCS range, especially in an outdoor range.

**Ground plane** - A conducting or reflecting surface that functions as a structure that creates an image of a radiating structure.

**Ground plane range** - An RCS measurement range utilizing the ground bounce interference pattern to improve radar system sensitivity by placing more apparent power on the target.

**I/Q** - In-phase/Quadrature. The orthogonal components that result from the process of coherent detection in a radar. Using these components, both the amplitude and phase of the scattered signal can be generated.

**Image** - A picture that maps a physical property to a spatial location. For example, a radar image maps the EM scattering properties of a target to locations in space.

**Incoherent Integration** - The process of integrating a radar signal after the detector circuit. This results in the loss of phase information, and yields an amplitude only result for the scattered signal. Used in some radar systems because of its ease of implementation.

**Inverse Synthetic Aperture Radar (ISAR)** - A Synthetic Aperture Radar (SAR) where the radar is held stationary as the target moves (rotates) to create a synthetic aperture.

**Isolation** - The ability of a device or system to separate the effects of multiple signals from one another.

**Jammer to Signal Ratio (J/S)** - A measure of power generated by a jammer relative to the radar signal from the target.

**Jet engine modulation (JEM)** - Modulation present in the radar returns received from a jet aircraft, caused by the rotation of the fan or turbine blades of the aircraft's engines. A similar effect is noted in the return from the blades of a helicopter.

**Linear polarization** - If the vector that represents the electric field (propagating electromagnetic wave) is always directed along a line, the field is said to be linearly polarized. Most radars utilize linear polarization.

**Maximum unambiguous range** - The range for which the round-trip transit time from radar to target to radar is equal to the period between two pulses.

**Mean, Arithmetic** - One type of numeric average. In a set of values, the number obtained from summing the values of the members of the set and dividing the result by the number of members in the set.

**Mean, Geometric** - One type of numeric average. In a set of values, the number obtained by taking the  $n$ th root of the product of the " $n$ " number of members in the set.

**Median** - In a set of numerical values, the "middle" value, that represents the point that one-half of the values are above and below.

**Modulation** - the fluctuation of the amplitude, frequency or phase of a radio signal, usually done intentionally to convey information.

**Monostatic RCS** - The reflectivity of a target when viewed by a radar which has its transmitter and receiver antennas at one location. In many cases the same antenna is used for both functions.

**Multiple-time-around echoes** - Returns received from beyond a radars maximum unambiguous range. These are caused by the reception of echoes due to pulses transmitted before the most recently transmitted pulse.

**Multipath propagation** - The term used for the reception of a radar return by two or more separate paths, such as seen when the return from a target on a radar range arrives by a direct path as well as from a reflection due to the ground plane. Because of the differing path lengths, there will be a phase difference between the two signals, resulting in either constructive or destructive interference.

**Near field** - The region in the vicinity of the transmitting antenna or radar target in which amplitude components of the field having range (R) dependence other than  $(1/R)$  cannot be neglected.

**Phase** - The sense of a periodic wave phenomenon relative to its origin.

**Phase error** - The error due to the deviation from an assumed perfect phase front that interacts with the radar target. For most systems it is desirable to have a phase error of less than 22.5 degrees.

**Polar plot** - Graphical representation of a radiation pattern in polar (r,q) coordinate form.

**Polarization** - Polarization of a radiated wave is defined as that property of a radiated electromagnetic wave describing the time varying direction and relative magnitude of the electric-field vector. Specifically, the figure traced as a function of time by the extremity of the vector at a fixed location in space, and the sense in which it is traced, as observed along the direction of propagation. Put in a less formal way, it is the orientation of the electric field radiated from an object, with respect to some reference, usually the ground. For radars, the sense of the polarization is usually defined as that of the electric field with respect to earth. Thus, a horizontally polarized wave is one where the electric field is parallel with the earth, while vertically polarized waves are those where the electric field is perpendicular to the earth. Because of loss consideration, most vhf/uhf radars tend to be horizontally polarized, while higher frequencies may be either horizontally or vertically polarized.

**Polarization scattering matrix** - The matrix created by putting the measured (predicted) co-polarized values of the radar target (HH, VV) along the main diagonal and the measured (predicted) cross-polarized values (HV, VH) in the off diagonal position.

**Probability Distribution Function (PDF)** - A statistical description of a complex target's RCS, giving the probability that the target's measured RCS falls within a small range of RCS values.

**Pulse compression** - The compression of the width of a radar's pulses after reception, accompanied by a corresponding increase in their amplitude. The compression is accomplished by coding the transmitted pulses via some modulation scheme and passing the received signals through a filter that decodes the modulation. Since the average transmitted power is directly proportional to pulse width, and the range resolution is inversely proportional to pulse width, pulse compression yields high-resolution without decreasing average power.

**Pulse Repetition Frequency (PRF)** - The number of pulse per unit of time.

**Pulse Repetition Interval (PRI)** - The time duration between pulses in the pulse train.

**Pulse Repetition Rate (PRR)** - The number of pulses per unit of time.

**Pulse width** - The time interval between the points on the leading and trailing edges at which the instantaneous value bears a specified relation to the maximum instantaneous value of the pulse.

**Pylon** - A wing shaped target support structure inclined toward the radar. The edge-on orientation gives a low RCS, while the metal construction provides the capacity to handle heavy targets.

**Quiet zone** - The volume in a compact range where "far field" conditions exist.

**Radar Absorbing Material (RAM)** - Any of a large class of materials that are designed to absorb electromagnetic radiation. Usually broken up into two main classes: dielectric and magnetic, where the absorption activity is caused by attenuation of the dielectric and magnetic fields, respectively.

**Radar Cross Section (RCS)** - The equivalent area required to intercept and radiate isotropically the same power as the target reflects toward the receiver. Usually measured in units of square meters or decibels with respect to a square meter.

**Range ambiguity** - Uncertainties in the measured or observed range of a target. In the case of pulsed radar, if the round-trip ranging time for the most distant target that may be detected is greater than the interpulse period, there is a possibility that the true range equals the observed range plus some integer multiple of the maximum unambiguous range.

**Range bin** - When processing RCS data, the particular memory location or counter to which a measured range value is assigned. If the return received is the result of range ambiguities, the range bin will contain values due to several ranges.

**Range gate** - In radars that employ analog signal processing, a high-speed electronic switch which briefly closes (gate opens) at a given point in each successive inter-pulse period, thereby passing on the returns received from a given range, or set of ambiguous ranges.

**Range resolution** - The minimum range by which two targets at the same azimuthal heading may be separated and their radar returns individually detected.

**Rectangular plot** - Graphical representation of a radiation pattern in rectangular (x,y) coordinate form.

**Reflectivity** - The degree to which an object or surface reflects incident radio waves.

**Resolution cell** - A rectangle or cell, whose sides are the minimum resolvable distance in range and the minimum resolvable cross-range distance.

**Shadow boundary** - The boundary that separates regions that are illuminated by direct radiation from those that are illuminated by reflected or diffracted radiation.

**Scattering center** - The apparent "point source" to which scattering can be. Complex targets may be represented by a many scattering centers, while a simple target may be represented by a few scattering centers.

**Scintillation** - The rapid fluctuation in the amplitude of the return received from a target. Due to changes in the relative distances of the various scattering elements making up the target. Changes may result from changes in distance, angles or aspect of the target, or vibrations that cause the changes to occur. Different from an apparent change in the center of reflection, known as **glint** (q.v.).

**Shadow plane range** - A modified ground bounce range where the base of the target support structure is below the shadow boundary (ground plane), and thus is partially shadowed from the radar, yielding a smaller background RCS.

**Signal to Clutter Ratio (S/C)** - The ratio of target echo power to the power received from clutter sources lying within the same resolution element.

**Signal to Noise Ratio (S/N or SNR)** - The ratio of the magnitude of a desired signal to that of the noise received by the system. Usually in terms of peak values in the case of impulse noise and in terms of root-mean-square values in the case of random noise. Usually stated in terms of decibels.

**Synthetic Aperture Radar (SAR)** - A radar using the motion of the radar past a target to simulate a large effective antenna aperture. This gives a much higher resolution image of the target than that resulting from the actual antenna aperture.

**Test body** - A structure used to mount a device (article) under test. It is designed to have a low radar cross section, provide an impedance match from test body to device under test to eliminate discontinuities, and provide the structural strength and stability to mount the body to a test setup, such as a pylon or foam column.

**Vector subtraction** - Electromagnetic (radar) waves or signals are vector quantities, since they have both an amplitude and phase component. As such, they are subject to cancellation by the method of adding to any given signal another signal of equal amplitude, but opposite phase. The resultant signal will be eliminated to the extent that the canceling signal matches the signal to be canceled. Although the resultant can be made equal to zero theoretically, there are practical constraints on this, chiefly the ability to match the desired phase. Because a change in phase can be equated to a change in distance, the ability to match the phase, and keep it matched is very dependent upon the physical stability of the system. Practically, this implies that vector subtraction becomes more difficult as the wavelength (frequency) gets shorter (higher). Other factors, such as drift due to equipment or environmental changes will also affect the ability to perform vector subtraction.

## ***Appendix III***

### **Abbreviations/Acronyms**

A/D	Analog-to-Digital
AM	Amplitude Modulation
CDF	Cumulative Distribution Function
CW	Continuous Wave
D/A	Digital-to-Analog
dB	Decibel
DFT	Discrete Fourier Transform
FFT	Fast Fourier Transform
FM	Frequency Modulation
FM/CW	Frequency Modulation, Continuous Wave
I/O	Input/Output
I/Q	In-phase/Quadrature
IF	Intermediate Frequency
ISAR	Inverse Synthetic Aperture Radar
JEM	Jet Engine Modulation
J/S	Jammer-to-Signal Ratio
LO	Local Oscillator
MMW	Millimeter Wave
PCM	Pulse Code Modulation
PDF	Probability Distribution Function
PRF	Pulse Repetition Frequency
PRI	Pulse Repetition Interval
PRR	Pulse Repetition Rate
RAM	Radar Absorbing Material
RF	Radio Frequency
RCS	Radar Cross Section
SAR	Synthetic Aperture Radar
S/C	Signal-to-Clutter Ratio
SNR or S/N	Signal-to-Noise Ratio
TWT	Traveling-Wave Tube
TWTA	Traveling-Wave Tube Amplifier
VSWR	Vertical Standing Wave Ratio

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## ***Appendix IV***

### **Radar Band Nomenclature**

<b>Radar Band</b>	<b>Frequency Range</b>	<b>Typical Uses</b>
HF	3 MHz- 30 MHz	Over-the-horizon (OTH) radar, combining very long-range with low spatial resolution and accuracy.
VHF	30 MHz- 300 MHz	Long-range, line-of-sight surveillance (200 to 500 km) with low-to-medium resolution and accuracy plus and freedom from weather effects.
UHF	300 MHz-1000 MHz	Same as VHF.
L	1 GHz-2 GHz	Long-range surveillance with medium resolution and some weather effects.
S	2 GHz-4 GHz	Short-range surveillance (100 to 200 km), long-range tracking (50 to 150 km) with medium accuracy, subject to significant weather effects in snow or heavy rain.
C	6Hz-8 GHz	Short-range surveillance, long-range tacking and guidance with high accuracy, subject to increased weather effects in snow or medium rain.
X	8 GHz-12 GHz	Short-range surveillance in clear weather or light rain; long-range tracking and guidance with high accuracy in clear weather, reduced to medium or short range (25 to 50 km) in rain.
Ku	12 GHz- 18 GHz	Short range- tracking and guidance (10 to 25 km), used especially when antenna size is very limited and when all-weather operations is not required. Wider use in airborne systems at altitudes above most weather.
K	18 GHz- 27 GHz	Seldom used because of water-vapor absorption centered at 22.2 GHz.
Ka	27 GHz- 40 GHz	Short-range tracking and guidance (10 to 25 km), used especially when antenna size is very limited and when all-weather operation is not required. Wider use in airborne systems at altitudes above most weather.
V	40 GHz- 75 GHz	Very short-range tracking (2 to 5 km); note that there is an atmospheric oxygen absorption line at 60 GHz, which generally precludes useful application in the vicinity of this frequency.
W	75 GHz- 110 GHz-	Very short-range tracking (2 to 5 km).
mm	110 GHz- 300 GHz	Very short-range tracking (2 to 5 km).

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